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The Behavioral Inhibition System and the Verbal Information Pathway to Children's Fears

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Abstract

The behavioral inhibition system (BIS) is the neurological substrate of trait anxiety and is linked to the development of anxiety disorders. Three experiments are reported that investigate the moderating influence of the BIS on one pathway to fear: threat information. In all studies, children were given verbal information about a set of novel animals and their BIS sensitivity was measured. The results suggest that BIS sensitivity (1) facilitates attentional biases to stimuli associated with threat information; and (2) facilitates behavioral avoidance of novel stimuli associated with threat information. This suggests a possible mechanism through which the behavioral inhibition system may promote the acquisition of animal fears.

The Behavioral Inhibition System and the Verbal Information Pathway to Children's Fears

Rachman (1977) proposed that fears could be acquired through three pathways: direct negative conditioning experiences, learning through observing others, and fear transmitted through verbal information. Retrospective studies have shown support for all three pathways (see King, Gullone & Ollendick, 1998; Merckelbach, De Jong, Muris & van den Hout, 1996 for reviews), however, the information pathway remains the least experimentally studied. Although Rachman did not formalize a mechanism through which fear information would have an effect, modern theories of fear development are intrinsically linked to the verbal information pathway. Davey (1997) has pointed out that there are two roles for moderating factors in conditioning models of fear acquisition. The first is through creating expectancies about the likely outcome of an encounter with a conditioned stimulus, CS (*expectancy evaluations*). The second is through moderating the aversiveness of the unconditioned stimulus (US) or US representation (*US Revaluation processes*). Threat information could affect both processes by (1) creating expectancies or beliefs about likely outcomes of subsequent conditioning episodes and (2) by revaluing a previously innocuous experience such that its mental representation comes to act as a negative US. In terms of expectancy evaluations, Davey (1997) noted a body of conditioning research suggesting that the core CS-US association driving acquired fear responses in humans is influenced by existing beliefs about the likely outcome of interacting with the CS. For example, a child believing that a dog will bite her who is subsequently bitten will have a stronger dog-trauma association than a child for whom the bite conflicts with their prior assumptions (see Field, in press).

Although retrospective studies have shown that threat information contributes to the development of fears, these reports will be prone to memory bias and forgetting of potentially important learning episodes (see King, Gullone & Ollendick, 1998; Merckelbach, De Jong, Muris & Van den Hout, 1996 for reviews). Field, Argyris & Knowles (2001) have developed an experimental paradigm for looking at the effects of fear information in the development of animal fear beliefs in children. Field et al., (2001) showed that 7-9 year old children's self-

reported fear beliefs about previously un-encountered toy monsters were influenced by whether they heard positive or threat information about the monsters. The source of the information also appeared to be important: fear beliefs increased significantly only when an adult provided the information and not when a peer provided the information. Field and Lawson (2003) improved on this methodology by using Australian marsupials (the quoll, quokka and cuscus), which were unfamiliar to children in the UK, as stimulus materials. For a particular child, one of the animals was associated with positive information, one was associated with threat information and they were given no information about the third. In these studies, threat information significantly increased children's fear beliefs as indexed by self-report, indirect measures of the beliefs (the implicit association task) and behavioral avoidance as measured by reluctance to approach a box inside which the animal was believed to be. Field, Lawson and Banerjee (2006) have shown that both implicit and explicit fear beliefs can last up to 6 months (see also Muris, Bodden, Merckelbach, Ollendick & King, 2003). Field (2006) has also shown that attentional biases to these animals can be induced by threat information.

Temperament has long been considered important in the acquisition of anxiety disorders: for example, H. J. Eysenck (1957) believed that anxiety was more likely in individuals scoring high on both Neuroticism and Introversion. Subsequently, Gray (1970, 1987, & 1988) suggested that trait anxiety could be viewed as bisecting the Neuroticism-Introversion space in H. J. Eysenck and S. B. G. Eysenck's (1969) two-factor personality model, but with a closer connection to neuroticism than introversion (Gray & McNaughton, 2003). Gray suggests that the dimension of trait anxiety is underpinned by a nervous system circuit, or set of circuits, known as the behavioral inhibition system (BIS). The anatomical substrate of the BIS is identified as the septo-hippocampal system (SHS), which is thought to control the experience of anxiety in response to anxiety relevant cues. The BIS is associated with sensitivity to punishment (or non-reward) and novelty cues and its outputs are increments in attention and arousal, but also inhibition of ongoing behavior. Gray and colleagues (Gray, 1987; Gray & McNaughton, 2003) have proposed that although activity in the BIS/SHS corresponds to state anxiety, differences in trait anxiety

arise from individual differences in the sensitivity of the BIS. This proposition is supported by research showing that measures of BIS correlate with both state anxiety (Carver & White, 1994; Gomes & Gomez, 2005; Zinbarg & Mohlman, 1998) and DSM-IV diagnosed anxiety disorders (Johnson, Turner & Iwata, 2003).

The idea that the BIS underlies a core temperamental trait important in the acquisition of fear re-occurs in the literature. Tellegen (1985) has identified a personality dimension of 'negative emotionality' that aligns to both anxiety (in terms of reactions to stress) and the BIS. In more recent models, such as Clark and Watson's (1991) tripartite model, 'negative emotionality' has been labeled 'negative affect'. Likewise, Rothbart, Ahadi and Evans (2000) identify 'fear' as one of four core temperaments in childhood and they too suggest that this temperamental trait is underpinned by the BIS. Developmental models of anxiety have also identified 'neuroticism/negative affect', which is again underpinned by the BIS, as having both a direct pathway to anxiety disorders and an indirect pathway via attentional biases to threat (Lonigan, Vasey, Phillips, & Hazen, 2004; Muris & Merckelbach, 2001). Despite the differing nomenclature, the BIS has been identified as underlying a core temperament that either lies on a continuum with anxiety disorders or acts as diatheses for anxiety disorders (see Fowles, 1987). In keeping with Gray's terminology, I shall call this temperament 'trait anxiety'.

In terms of how the BIS interacts with the verbal information pathway to fear, there are two hypotheses that follow directly from past research on fear information, predictions from the BIS, and Lang's (1985) observation that emotion is comprised of subjective states and associated cognitions, physiological states, and behavioral changes. First, in one interpretation of the model (see Zinbarg & Mohlman, 1998), the BIS is regarded as influencing motivation and, therefore, performance aspects of what has been learnt. As such, trait anxiety would be positively associated with avoidance motivation and hence performance aspects of avoidance behaviors (addressing also Lang's behavioral component of emotion). As such, those high on BIS sensitivity and, therefore, trait anxiety would show greater avoidance of previously novel stimuli after threat information. Second, Gray and McNaughton (2003) note that those high on BIS

sensitivity/trait anxiety will attend more to anxiogenic stimuli, therefore, the strength of attentional bias following threat information (Field, 2006) will be stronger in those high on BIS sensitivity/trait anxiety (which addresses Lang's cognitive component of emotion).

The experiments reported here aim broadly to test these ideas by looking at the moderating effect that Gray's BIS has on the effect of threat information on children. Experiment 1 looks at an adaptation of Carver and White's (1994) behavioral inhibition scale for children. Given that the outputs of the BIS are increments in attention and the inhibition of ongoing behavior, Gray's theory predicts that children high on BIS sensitivity should also acquire stronger attentional biases (Experiment 2) and show more avoidance behavior (Experiment 3) to animals about which they have heard threat information than children low of BIS sensitivity.

EXPERIMENT 1A

To look at the moderating influence of the BIS on the effect of threat information, BIS sensitivity has to be measured. Carver and White (1994) developed the CW-BIS to measure BIS sensitivity in adults: a seven-item scale with a 4 point Likert response scale. The CW-BIS has: (1) convergent and discriminant validity shown by correlations with associated measures; (2) predictive validity in a behavioral task; and (3) reasonable test-retest reliability over 8 weeks, $r = .66$ (Carver & White, 1994). The internal consistency of the scale is above the accepted cut-off of .70 across a variety of studies: $\alpha = .74$ (Carver & White, 1994), .76 (Jorm et al., 1998) and .72 (Gomez & Gomez, 2005). The questionnaire also has factorial validity in both nonclinical samples (Carver & White, 1994; Johnson et al., 2003; Jorm et al., 1998; Ross, Millis, Bonebright, & Bailey, 2002) and samples with anxiety disorders (Campbell-Sills, Liverant, & Brown, 2004). The scale correlates with other measures of trait anxiety such as the Spielberger Trait Anxiety Inventory ($r = .75$, Gomes & Gomez, 2005; $r = .45$, Zinbarg & Mohlman, 1998) and the Manifest Anxiety Scale ($r = .58$, Carver & White, 1994). BIS scores are also significantly higher in people with a DSM-IV based lifetime diagnosis of anxiety disorders (Johnson et al., 2003). However, the CW-BIS has not been used in children, and no child version of the scale exists. To this end,

Experiments 1A and 1B sought to adapt Carver and White's scale for use in children under 10 and obtain some preliminary data about its suitability to use in the subsequent experiments both in terms of its reliability and its relationship to an existing measure of child anxiety.

Method

Participants

The participants were 30 children (19 Males and 11 Females) aged 8-9 years ($M = 9.09$, $SD = 0.34$). In all of the experiments in this paper this age range was selected because normative fears are beginning to focus on animals at this developmental period (Field & Davey, 2001). Parental consent was obtained prior to data collection. Children were tested individually.

Materials

Behavioral Inhibition Scale (CW-BIS)

Although the CW-BIS has shown good psychometric properties in adults, working with young children necessitated simplifying the phrasing of questions 3, 5 and 7: for example, question 3 was changed from 'Criticism or scolding hurts me quite a bit' to 'Getting told off upsets me' because the youngest children did not understand the words 'criticism' or 'scolding' (see appendix A for a list of questions). The points on the Likert scale were also changed from 'agreement-disagreement' to 'not at all', 'not really', 'sometimes' and 'always'. As such, the scale ranged from 7-28, with a high score reflecting high BIS sensitivity.

Although not in public domain at the time when the studies reported in this paper were conducted, Muris, Meesters, de Kanter, & Timmerman (2005) have recently reported data for a similar adaptation of Carver and White's BIS scale in a non-clinical sample of similar age to the present experiments (8-12 year old children). Like the present questionnaire, Muris et al. rephrased some of the questions from the adult measure (see appendix B). In addition, they used a response scale of 'not true', 'somewhat true', 'true', and 'very true'. One important difference between Muris et al.'s CW-BIS and our adaptation and Carver and White's adult scale

is that the final question is not reverse-phrased in Muris et al.'s version. Muris et al. confirmed that the CW-BIS had one underlying factor with reliability, $\alpha = .78$. These data indicate that a modified version of CW-BIS is appropriate to measure BIS in a child sample. Internal consistency for the current sample was, $\alpha = .75$.

Screen for Child Anxiety Related Disorders (SCARED):

To test the concurrent validity of the child version of the CW-BIS, it was compared against the Screen for Child Anxiety Related Disorders (SCARED). The SCARED (Birmaher, Brent, Chiappetta, Bridge, Monga, et al., 1999; Birmaher, Khetarpal, Brent, Cully, Balach et al., 1997) is a 41-item self-report questionnaire that measures panic, generalized anxiety disorder (GAD), separation anxiety, social anxiety, and school anxiety. In child clinical samples, child and parent versions of the SCARED correspond moderately (r s ranged from .20 to .47 and .22 to .39) and the scale has good internal consistency (Cronbach's α ranged from .74 to .89 and .78 to .87), test-retest reliability was good (intraclass correlation coefficients ranged from .70 to .90 in the 1997 study), and consistently has a five factor structure (Birmaher et al., 1997, 1999). The five factor structure has been confirmed in age-comparable non-clinical samples (Hale, Raaijmakers, Muris & Meeus, 2005; Muris, Merckelbach, Schmidt & Mayer, 1999), as has the internal consistency: α ranging from .64 to .94 (Muris et al., 1999), .74 to .95 (study 1) and .73 to .93 (study 2) (Muris et al., 1998b), .74 to .95 (study 1), .72 to .95 (study 2) (Muris, Merckelbach, van Brakel, Mayer, & van Dongen, 1998a) and .76 to .94 (Muris & Steerneman, 2001).

The SCARED is also invariant across gender (Hale et al., 2005) and is highly correlated with measures of trait anxiety such as the Spielberger Trait Anxiety Inventory for Children (STAIC), $r = .69$ (Muris, Mayer, Bartelds, Tierney & Bogie, 2001) and $r = .73$ (Muris et al., 1998a), the Revised Child Manifest anxiety Scale (RCMAS), $r = .86$ (Muris et al., 1998b) and the Fear Survey Schedule for Children, which measures normative fear, $r = .64$ (Muris & Steerneman, 2001) and $r = .67$ (Muris et al., 1998b). The SCARED shows similar test-retest stability to the STAIC (Muris et al., 2001) and it successfully distinguished anxious children from those with externalizing problems (Muris, Merckelbach, Mayer & Prins, 2000).

Procedure

Children completed computerized versions (using custom-written software in Visual Basic.net by the author) of the BIS-CW and SCARED questionnaires in randomized order.

Results

Cronbach's α for the panic, GAD, separation anxiety, social anxiety and school phobia subscales of the SCARED were .86, .82, .78, .72, and .52 respectively. CW-BIS shared 23.91% of its variance with the SCARED, $r = .49$, $p < .01$. For the SCARED subscales, with the exception of school avoidance ($r = .01$, $p = .98$), the correlation coefficients with BIS were very similar to the total scale: $r_s = .50$ (separation anxiety), $.44$ (panic), $.46$ (GAD), and $.47$ (social anxiety), all $ps < .05$. These findings are consistent with Muris et al.'s (2005) finding that their CW-BIS correlated highly with DSM-IV diagnosed anxiety (measured using the RCADS), $r = .58$. As such, the adapted CW-BIS used in the current studies correlates with enduring anxiety to the same extent as other child measures of anxiety disorders and a different adaptation of the CW-BIS.

EXPERIMENT 1B

The publication of Muris et al.'s (2005) child version of the CW-BIS subsequent to our Experiments made it important to check the relationship between this scale and our own. A close correspondence between the two adaptations would increase confidence that the psychometric properties demonstrated by Muris et al. (2005) apply to the version of the CW-BIS used in Experiments 2 and 3.

Method

Participants and Procedure

29 children (10 Males, 18 Females and one undisclosed) aged 7-10 years ($M = 8.67$, $SD = 0.94$) participated. Parental consent was obtained and children were tested individually. Children completed our adapted CW-BIS and that of Muris et al. (2005) in a random order.

Results

For the Muris CW-BIS, the reliability was high, $\alpha = .83$, the only item that would improve reliability if it were deleted from the scale was item 5 (α if item 5 deleted = .87). For our adaptation of the CW-BIS, reliability was also high, $\alpha = .68$, which approximates the recommended value of .70. Like Muris et al.'s scale, reliability would be improved by deleting item 5, but also by deleting item 7 (in both cases α if item deleted = .70). Items 5 and 7 had the lowest correspondence between scales ($r_s = .39$ and $-.02$ respectively) and item 7 is the one item that had different phrasing between the scales: it was reversed phrased in our version but not on the Muris et al. version. For the purpose of this study, the important statistic is the correlation between the two child-adapted versions of the CW-BIS, which was very high, $r = .87$.

Discussion

Experiments 1A and 1B sought to test whether the child adapted CW-BIS would work as an effective measure of trait anxiety as it relates to Gray's behavioral inhibition system. Experiment 1A showed that the size of relationship between the child adapted CW-BIS used in the present studies and another measure of general anxiety was consistent with that found in past research (e.g. Muris et al. 2005). Experiment 1B sought to directly compare two child adapted versions of the CW-BIS. Excellent correspondence between the child-adapted CW-BIS used in this series of studies and a version with known psychometric properties was found. However, items five and seven lowered the reliability on our version of the CW-BIS. As such, the remaining studies' results will be reported both for the child adapted CW-BIS overall, but also for CW-BIS totals calculated using only items 1, 2, 3, 4, and 6.

EXPERIMENT 2

The effect of threat information on children's fear beliefs is now well-replicated (Field & Lawson, 2003; Field et al., 2001, 2006). However, this raises the question of how the verbal information pathway contributes to enduring fears. In keeping with Lang's (1985) suggestion that

emotions have a cognitive component, some explanations of clinical anxiety suppose that high level cognitive processes cause and maintain the anxiety. Indeed, cognitive biases appear to be an important part of the etiology of all anxiety disorders (APA, 1994). For example, Williams, Watts, Macleod and Mathews (1997) propose that (1) anxiety is characterized by an attentional bias favoring threat stimuli; (2) that these biases are vulnerability factors for clinical anxiety; and (3) attentional biases are exacerbated when state anxiety is high. This final proposition relates directly to Gray's ideas about the BIS: people with high BIS sensitivity/trait anxiety should devote attentional resources to anxiogenic stimuli.

Threat information could have a causal impact on the development of anxiety by creating attentional biases: training non-anxious adults to have attentional biases using verbal information increases their state anxiety (Mathews & MacLeod, 2002), and attentional biases to a novel animal previously associated with threat information can be observed in nonanxious children (Field, 2006). However, Field's effects were weak implying that external factors, such as temperament, may have moderated the induced bias. Field (2006) did not measure temperamental factors in his study, but BIS sensitivity is an obvious candidate as a moderator for several reasons. First, Gray and McNaughton (2003) suggest that activation of the BIS leads to increased attention, and an overactive BIS appears to be related to deeper processing of peripheral cues in adults (Poy, Eixarch, & Avila, 2004). Poy et al. (2004) concluded that higher levels of BIS allow earlier and more frequent detection of aversive stimuli. Second, Gomez and Gomez (2002) showed that BIS sensitivity in adults was associated with negative emotional processing: adults high on behavioral inhibition sensitivity recognized, recalled and generated significantly more negative words than those high on the behavioral approach scale. These findings suggest that high BIS sensitivity facilitates attentional bias towards threatening material. Finally, Lonigan et al. (2004) hypothesize that 'negative affect', which the BIS underpins, has a causal relation to anxiety disorders both directly and indirectly through facilitating attentional biases. Experiment 3 tests whether the attentional bias created by threat

information is moderated by the BIS. It is predicted that as BIS sensitivity increases so will the attentional bias induced by threat information.

Method

Participants

Sixty children (28 Males and 32 Females) aged 6-9 years ($M = 7.95$, $SD = 1.25$) participated and were tested individually. Parental consent was obtained before the study took place.

Materials

Animals

Pictures of three Australian marsupials, the Quoll, the Cuscus and the Quokka were used. These were animals about which the children had no prior experience and so they would have no prior fear expectations. Each picture had a caption below it that clearly named the animal.

Information

The threat information and positive information used by Field and Lawson (2003) and Field (2006) were used in this experiment (Appendix C). The name of the animal in the information was changed to fit the experimental condition. The two sets of information are approximately matched for length and word frequency (see Field & Lawson, 2003).

Behavioral Inhibition Scale (CW-BIS)

The adapted version of Carver and White's (1994) behavioral inhibition scale (CW-BIS) reported in Experiment 1A was again used. Cronbach's alpha in the current sample was $\alpha = .72$.

Pictorial Dot-Probe Task

The dot-probe task measures attentional bias towards negative pictures (e.g. Bradley, Mogg, White, Groom, de Bono, 1998; Bradley, Mogg, Falla, & Hamilton, 1998; Mogg & Bradley, 1999). In this computerized task, two pictures appear on the screen (one on the left- and one on the right-hand side) for a short time then vanish revealing a probe behind one of the pictures. Participants have to identify the type of probe by pressing 'A' on the keyboard if the probe is ':'

or pressing 'L' if the probe is '..'. By measuring reaction times to identify the probe it is possible to infer at which picture the participant's attention is focussed: In our task, for example, if a picture of a quoll and a cuscus appeared on the screen and the probe appeared behind the quoll, if the person was attending to the quoll then they would be quicker to identify the probe than if they were attending to the cuscus (because their attentional focus is already at the side of the screen at which the probe appeared). By using different pairs of animals it was possible to see whether a child was attending to one type of animal more than another.

Three types of picture pair were used: (1) *Positive-No*, the animal about which the child heard positive information appeared on the screen alongside the animal about which no information was given; (2) *Threat-No*, the animal about which the child heard threat information appeared on the screen alongside the animal about which no information was given; and (3) *Threat-Positive*, the animal about which the child heard threat information appeared on the screen alongside the animal about which the child heard positive information. For each animal two different pictures were used, making 4 different combinations of pictures within each type of picture pair. To control for whether a particular picture appears on the left or right of the screen, each of these 4 different pictures appeared twice with the screen location for each picture being reversed. This resulted in 8 presentations for each type of pair. Each of these 8 presentations had to be repeated with each of the two probes ('.' and '..'), and each of these probes has to appear equally on the left and right of the screen. Therefore, in total, within each of the three pair types there were 32 presentations, making 96 presentations in all. Reaction times to detect the probe were measured on each trial. Preceding the main trials, there were 24 practice trials in which reaction times were not measured.

On each trial, a fixation cross appeared for 500ms, followed by the picture pair for 500ms, and immediately followed by the probe. Each picture was 350×350 pixels. This task was custom written by the author using Visual Basic 6, with ExacTicks 1.1 (Ryle Design, 1997) used to ensure ms accurate reaction time measurements. A Pentium III Toshiba Tecra 8000 laptop computer running Windows 2000 was used to administer the dot-probe task.

Procedure

Children were divided randomly into three counterbalancing groups: (a) *Quoll Threat*: received threat information about the quoll, positive information about the cuscus and no information about the quokka; (b) *Cuscus Threat*: cuscus (threat information), quokka (positive information) and quoll (no information); and (c) *Quokka Threat*: quokka (threat information), quoll (positive information) and cuscus (no information).

For a given child, the CW-BIS was first administered: The child was helped to use the questionnaire on a question-by-question basis. Next, the child was shown pictures of all three animals that were then placed in front of the children in a position where they could be clearly seen. The experimenter then read the children the two sets of informationⁱ. The animals that were the subject of the information depended on the group to which the child was assigned and the order of positive and threat information was counterbalanced within these groups. Finally, the pictorial dot-probe task was administered. At the end of the experiment, the children were debriefed and given factual information and worksheets about the animals.

Results

Throughout this paper, all significant effects are reported at $p < .05$ unless otherwise stated and effect sizes are reported as Pearson's r where interpretable (i.e. when the degrees of freedom for the effect are 1). BIS was treated as a continuous variable throughout because of the statistical problems in creating artificial categories from continuous variables (see MacCallum, Zhang, Preacher & Rucker, 2002).

General Analysis

In all analyses trials in which children incorrectly identified the probe (i.e. gave the wrong response) were excluded, and as is recommended for reaction time data, a standard deviation based cut-off was used (see Ratcliff, 1993): for each child reaction times greater than 2 standard deviations above their mean were excluded.

Threat-No Trials: The dot-probe task is designed to measure visual focus. The theory is that if the probe appears on the same side of the screen to which the person is attending then reaction times will be faster than if it appears on the opposite side of the screen. In the present context we are particularly concerned with whether the children are attending to the animal about which they heard threat information, therefore, the question becomes: are reaction times faster when the probe appears in the same location as the animal about which children heard threat information than when the probe appears in the opposite location (i.e. in the same location as the animal about which the children heard no information). To simplify the data analysis, trials were first collapsed into two categories: trials on which the probe appeared in the same location as the animal about which threat information had been heard ('same' trials), and trials on which the probe appeared in the opposite location to the animal about which threat information was given ('different' trials). To further simplify things, the mean reaction time for the 'same' trials was subtracted from the mean reaction time for 'different' trials. The result was a single attentional bias score for each child. A positive score meant that the child responded quicker to 'same' trials than 'different' trials: that is, they responded quicker when the probe and the threatening animal appeared at the same location. Put another way, they were, on average, paying attention to the animal about which they heard threat information.

Positive-No Trials: As with the threat-no trials, data were collapsed to produce a single attentional bias score for each child. This time, a positive score meant that children were, on average, paying attention to the animal about which they heard positive information.

Threat-Positive Trials: data were again collapsed to produce a single attentional bias score for each child. This time, however, a positive score meant that children's attention was, on average, focused on the animal about which they heard threat information in preference to the animal about which they heard positive information.

Figure 1 shows the mean attentional bias scores for the three different types of trial. One-sample *t*-tests revealed that attentional bias scores were not significantly different from zero for Threat-No Trials, $t(59) = 1.39$, and for Positive-No Trials, $t(59) = -1.15$, but were for Threat-

Positive trials, $t(59) = 2.84$, $p < .01$. This indicated that overall an attentional bias was shown only for trials in which the positive and threatening animal appeared on the screen: children's attention was more likely to be focused on the threatening animal when the probe appearedⁱⁱ.

Insert Figure 1

Does BIS sensitivity Moderate the Attentional Bias?

The focus of this paper is to see whether BIS sensitivity moderates the threatening information pathway to children's fears. According to Baron and Kenny (1986), to determine whether a continuous variable (in this case BIS) is a moderator of a categorical independent variable (in this case the type of information), one need only regress the attentional bias score onto BIS, the type of trial or information (coded using standard dummy variables), and the product of these predictors (the $BIS \times \text{Trial Type}$ interaction). If the interaction is significant when controlling for BIS and the type of trial/information, then BIS moderates the effect that different types of information have on fear beliefs.

This analytic strategy assumes that the independent variable (information) was manipulated by giving different children different types of information. In the current design, however, all children received all types of information. Judd, Kenny and McClelland (2001) recommend two techniques for overcoming this problem, one of which is multilevel modeling, which is the approach adopted throughout this paper. Multilevel modeling is multiple regression in which the hierarchical structure of the data is accounted for within the analysis structures (see, for example, Goldstein, 1995). In this case, the hierarchy is that treatment conditions (different types of information or dot-probe trial) were nested within children: children become the unit of investigation. By looking at the data hierarchically Baron and Kenny's (1986) method for determining moderation (by looking for an information type \times BIS interaction) is easily applied to a situation in which treatment conditions are nested within children.

A multilevel model was constructed in which reaction times in milliseconds were the outcome variable. According to Baron and Kenny (1986) the interaction term must be explored

while controlling for the main effects of the independent variable and the moderator, as such CW-BIS scores and type of dot-probe trial were included in the model. Three different types of trials were used in the task (Threat-No, Positive-No, and Threat-Positive) and these were coded using two dummy variables in which the Positive-No trials acted as the baseline category. The beta-coefficient for the first dummy variable represented the difference between the threat-No trials and the Positive-No Trials; through subtraction, this coefficient quantifies the difference between the threatening and positive animal. The beta-coefficient for the second dummy variable represented the difference between the Threat-Positive trials and the Positive-No Trials; through subtraction, this coefficient represents the difference between the threatening and control animal. The key variables for testing the moderating influence of BIS on attentional bias were two interaction terms that were created by computing variables that were the product of each dummy variable and CW-BIS. As recommended by Baron and Kenny (1986), the model included the main effects of CW-BIS and type of dot probe trial (two dummy variables) as well as the CW-BIS \times dot probe trial interactions (two variables).

The interaction between the first dummy variable and BIS was significant ($b = 25.06$, $SE = 9.64$, $\eta^2(1) = 6.76$, $p = .009$) indicating that BIS was a significant moderator of the attentional bias towards the threatening animal over the positive animal. The interaction between the second dummy variable and BIS was also significant ($b = 22.71$, $SE = 9.64$, $\eta^2(1) = 5.55$, $p = .019$) indicating that BIS was also a significant moderator of the attentional bias towards the threatening animal over the no information animal. In both cases, as BIS increased the tendency to attend to the threatening animal at the time when the probe appears increased also.ⁱⁱⁱ

Discussion

The results from the dot-probe task seem to support Field's (2006) finding that threat information is sufficient to induce an attentional bias for certain kinds of novel animals. However, in addition, this experiment has shown that this bias is moderated by BIS sensitivity/trait anxiety. As such, the results address whether the BIS moderates the contribution

of the threat information pathway to the cognitive component of the anxiety response (Lang, 1985). As scores on CW-BIS increased the tendency towards attending to the animal about which they had heard threat information in favor of both the animal about which they heard positive information and the animal about which they heard no information increased also. These findings show that cognitive components of the anxiety emotion can be created by an interaction of threat information and BIS sensitivity/trait anxiety.

EXPERIMENT 3

Experiment 3 progresses to look at the behavioral component of anxiety (Lang, 1985). There are several reasons why this step is important. First, one of the outputs of the BIS is the inhibition of ongoing behavior (Gray & McNaughton, 2003). Second, studies have shown that anxiety disorders are closely associated with inhibited approach behavior (Caspi, Henry, McGee, Moffitt & Silva, 1995)— avoidance behavior, which could be seen as an extreme form of inhibition, is a key diagnostic features of specific phobias in DSM-IV (APA, 1994). Finally, threat information increases behavioral avoidance of previously novel animals (Field & Lawson, 2003). Given that threat information leads to inhibition of approach behavior to novel animals and the BIS is directly implicated in the inhibition of ongoing behavior, BIS sensitivity should moderate the relationship between threat information and behavioral avoidance. As BIS sensitivity increases children should become more inhibited about approaching animals about which they have heard threat information.

Method

Participants

The participants were 127 children (63 Males and 64 Females) aged 6-9 years ($M = 8.08$, $SD = 1.25$). Parental consent was obtained prior to the study and children were tested individually.

Materials

The same animals and information were used as in Experiment 2. The child-adapted CW-BIS was again used. Internal consistency for this sample was $\alpha = .77$.

Touch-Box Task

Avoidance was assessed with a behavioral task used by Field & Lawson (2003) and Field et al. (2006). For each animal, a touch box was created consisting of a large wooden box, with a round hole at one end and a plaque showing the name of its animal inhabitant. A Hessian curtain covered the hole with a slit in the middle such that the child could put their hand into the box but could not see what the box contained. Each box contained a furry cuddly toy.

Procedure

The procedure was the same as Experiment 2 except that instead of the dot-probe task, after the information had been given children were asked to stroke the animals by placing their hands into boxes on a table approximately 2.5 meters from the table at which they had been seated. The animals were kept in the same arrangement for all children, and all children were asked to approach the animals in the same order (the quoll first, then the quokka, then the cuscus). This meant that over all the children, the order of approach was varied across the type of information. The experimenter asked the child to stroke each animal individually. The behavioral approach task was introduced with the words 'Would you like to stroke the animals?' followed by 'start with the quoll,' then, when the quoll had been stroked, or refused, 'what about the cuscus?' and finally 'what about the quokka?' For each animal, the experimenter started a stopwatch on saying the animal's name and stopped it when the child put their hand through the Hessian curtain as far as their wrist. If a child did not stroke a particular animal after fifteen seconds, the experimenter took this as a sign of unwillingness to do the task and for ethical reasons moved on to the next animal. Afterwards, all children were told that the animals in the boxes were not in fact real.

Results

Fourteen children would not approach one or more of the boxes within the 15s limit. These children were given a score of 15s for any boxes that they refused to approach^{iv}. The Latencies to approach the boxes were positively skewed (Kolmogorov-Smirnov z s = 1.89, 2.82, 3.09 for the threat, positive and no information boxes respectively) and so were transformed using the natural log of the score. The resulting distributions were not significantly different from normal (Kolmogorov-Smirnov z s = 0.77, 1.04 and 1.17 for the threat, positive and no information boxes respectively). Figure 2 shows the mean log-transformed approach times for the three boxes: it clearly shows that approach times for the box containing the threat-information animal were longer than for the other two boxes.

A one-way repeated measures ANOVA revealed a significant main effect of the type of box^v, $F(1.90, 239.52) = 104.69$, $p < .001$. Bonferroni corrected post hoc tests revealed a significant difference between the threat information box and the positive information box, $CI_{99.98} = 0.55$ to 1.04 , $t(126) = 12.63$, $p < .001$, $r = .75$; the threat information box and the no information box, $CI_{99.98} = 0.44$ to 0.92 , $t(126) = 10.89$, $p < .001$, $r = .70$; but not the positive information box and the no information box, $CI_{99.98} = -0.32$ to 0.08 , $t(126) = -2.23$, ns , $r = .19$.

As in the previous experiments a multilevel model was used to ascertain whether BIS moderated the behavioral avoidance created by threat information. For these data, log approach times (described above) were the outcome variable. CW-BIS and the type of animal in the touch box were included as predictors. The type of animal had three levels and it was coded using two dummy variables: the beta-coefficient for the first represented the differences between the box containing the threat information animal and the no information animal (*NegNo*) and the beta-coefficient for the second represented the differences between the box containing the positive information animal and the no information animal (*PosNo*). Two interaction terms were created by computing variables that were the product of the *NegNo* dummy variable and BIS, and the product of the *PosNo* dummy variable and BIS. If these

interactions are significant after controlling for the main effects of BIS and the type of touch box then BIS moderates the effect that information had on avoidance (see Baron and Kenny, 1986).

The *NegNo* × BIS interaction ($b = 0.05$, $SE = 0.02$, $\chi^2(1) = 7.66$, $p < .01$) was significant indicating that BIS is a significant moderator of the effect that threat information has (relative to no information). The *PosNo* × BIS interaction ($b = -0.07$, $SE = 0.02$, $\chi^2(1) = 16.35$, $p < .001$) was also significant, indicating that BIS also moderated the effect that positive information (relative to no information) had on approach times to the boxes.^{vi}

Discussion

Experiment 3 replicated findings by Field & Lawson (2003) and Field et al. (2006) showing that threat information about a novel animal was sufficient to promote behavioral avoidance whereas positive information facilitated approach. In addition, the moderator analysis demonstrated that, as predicted, as BIS sensitivity increased so did avoidance of the threat animal relative to the control. BIS sensitivity also moderated the effect of positive information: as BIS sensitivity increased reaction times to approach the positive animal decreased relative to the control. This later interaction is inconsistent with Gray's (1988) model in which susceptibility to reward stimuli is conceptualized as constant along the dimension of trait anxiety but changes as a function of impulsivity, which is driven by inputs to the behavioral activation system, or BAS (see Figure 12.1 in Gray & McNaughton, 2003). The moderating effect of CW-BIS on the effect of positive information on approach behaviour could, in part, reflect the fact that the CW-BIS overlaps with the 'reward responsiveness' subscale of Carver and White's BAS measure: a medium correspondence between these scales, $r = .27$ to $.30$, has been reported in several studies (Campbell-Sills et al., 2004; Carver & White, 1994; Franken, Muris & Rassin, 2005; Johnson et al., 2003; Jorm et al., 1998). The CW-BIS has also been shown to correlate with reward dependence, $r = .42$ (Carver & White, 1994). Reward responsiveness would be expected to moderate the effect of positive information on approach times to the extent that a child regards approaching an animal they know to be safe as rewarding. However, the correspondence

between CW-BIS and reward responsiveness is too low to fully explain why CW-BIS moderated the effect of positive information on approach behavior and this finding raises questions about either the specificity of the CW-BIS, or Gray's conceptualization of trait anxiety/impulsivity as outputs of the BIS/BAS respectively.

GENERAL DISCUSSION

The three experiments in this study have replicated past work (Field et al., 2001, 2006; Field & Lawson, 2003; Muris et al., 2003) that has shown that threat information is sufficient to change fear beliefs and facilitate behavioral avoidance of a novel animal in children. As such, a growing body of evidence is now accumulating that fear expectancies can be changed in children through verbal information. However, more important, the current experiments have shown that the trait anxiety/BIS sensitivity has a role to play: it facilitates the effect of threat information on behavioral avoidance and attentional biases following threat information.

Clinical Implications

In terms of how anxiety disorders develop, all of these findings support Rachman's (1977) idea that information is a viable pathway by which fears develop—at least in the sense that threat information seems to enhance fear beliefs, attentional bias to threat and avoidance. However, they also suggest that the trait anxiety/BIS sensitivity facilitates some of these processes. Davey's (1997) conditioning model of fear acquisition features fear expectancies as a core influence on the strength and speed at which associations are formed between an innocuous CS and an anxiety-evoking US. The current results clearly show that fear information creates the kinds of expectancies that Davey suggests would facilitate the acquisition of fear responses through subsequent direct conditioning experiences. One interesting feature of Davey's model is the exclusion of temperamental factors as an influence on conditioning. The finding that the BIS (in terms of its behavioral outputs) interacts with threat information to facilitate attentional bias and behavioral avoidance has two implications for Davey's model. As Davey acknowledges, learning history is an important component of conditioning (see also, Field,

in press) and the fact that BIS facilitates avoidance suggests that children high on BIS sensitivity who are given threat information about a novel animal are more likely to avoid that animal. This avoidance means that their learning history will be less varied and consequently be less likely to include positive encounters than a child who has not avoided the animal. Conditioning theory predicts that a subsequent traumatic encounter with the animal would, therefore, have greater impact because the contingency between the animal and threat outcomes will be stronger than in a child who has not avoided the animal in the past and has a more varied learning history with that animal (Field, in press). The second implication is that during a traumatic incident, a child high on trait anxiety/BIS sensitivity will be paying more attention to the animal about which they have negative expectancies and less attention to peripheral cues compared to a child with low BIS sensitivity. Davey's model does not explicitly discuss the role of attention during conditioning but it is clear from models of conditioning such as Mackintosh (1975) and Kruschke (2001) that the associability of potential stimuli depends very much on the attentional resources they garner. As such, the present data suggest two important developments for Davey's model.

The results of Experiments 1-3 are also consistent with several temperament-based models of anxiety acquisition (e.g. Clark & Watson, 1991; Gray & McNaughton, 2003; Lonigan et al., 2004; Muris & Merckelbach, 2001; Rothbart et al., 2000 and Tellegen, 1985). Nearly all of these models directly implicate the BIS as a biological system that underpins a temperament (variously labeled 'negative affect', 'negative emotionality', 'fear' or trait anxiety') that acts as a vulnerability to clinical anxiety. These models would predict that this temperament would interact with fear learning processes (such as threat information), and both Experiments 2 and 3 support this proposition: BIS sensitivity moderated both the effect of threat information in creating attentional biases to previously neutral stimuli, and behavioral avoidance following threat information. In short, the degree to which threat information facilitates processes and behaviors consistent with clinical anxiety depends upon trait anxiety/BIS sensitivity.

Temperament has also been key in cognitive models of anxiety development: Williams et al. (1997) and Mathews and MacLeod (2002) have proposed that trait anxiety (and, therefore,

the BIS) is a predisposing factor for attentional biases to threat information, and Lonigan et al.'s (2004) concur by suggesting that 'negative affect', as underpinned by the BIS, influences attentional bias to threat. As we have seen, the results from Experiment 2 are completely consistent with predictions from these cognitive models: as BIS sensitivity increased, the attentional bias induced by threat information increased also. The current work compliments recent demonstrations by Mathews and colleagues (e.g. Mathews & MacLeod, 2002; Mathews & Mackintosh, 2000) that attentional biases can be trained. However, there are two important differences. First, these results show that a bias can be induced using a very small burst of threat information (Mathews and colleagues typically employ extensive numbers of training trials), and also that the effect of this short burst of information on inducing a bias is dependent upon BIS sensitivity. Mathews and colleagues have also shown that inducing such biases increases state anxiety, and in doing so they have convincingly shown a causal link between acquired attentional biases and state anxiety. By inference, the current studies also hint at how the fear information pathway works: it may lead to anxiety directly (Field, 2004) but also through induced attentional biases, which themselves cause state anxiety. Further research should disentangle these possibilities.

Finally, Öhman and Mineka (2001) have stressed the importance of evolution on the development of fears. The stimuli used in the present studies were not ones typically found to be 'fear relevant' (in an evolutionary sense). This decision was deliberate because the stimuli needed to be novel to control for prior experience with the animals. However, the fear information pathway would be expected to interact with the evolutionary fear relevance of the animal. An obvious area for future work is to look at how BIS sensitivity, fear information and fear relevance of the stimuli interact in creating attentional biases and avoidance behavior.

Limitations

One limitation to the current Experiments is that they looked only at how BIS sensitivity interacts with verbal information to create cognitive and behavioral components of the fear

emotion. As such, although the experiments do show that BIS sensitivity and verbal information interact to create cognitions and behaviors consistent with anxiety, we do not know whether there was an effect on subjective or physiological states of anxiety either directly, or as a consequence of the acquired attentional bias or avoidance behavior.

A related concern is that the studies have not, for ethical reasons, looked at how BIS sensitivity might interact with verbal information to create phobic levels of anxiety. Although the studies have shown how verbal information and BIS sensitivity interact to create cognitions and behaviors exhibited by clinically anxious individuals (i.e. attentional biases to threat and avoidance), phobic levels of avoidance and psychological distress were not induced. Further research is necessary to determine how the cognitive biases and avoidance behavior that have been demonstrated here might, in the long term, promote phobic levels of anxiety. One way, as discussed above, is through interacting with other learning processes. However, such an interaction depends upon the attentional biases and avoidance behavior created by BIS sensitivity and verbal information persisting beyond the immediate laboratory setting. Although Field et al. (2006) have shown that self-reported fear beliefs created by verbal information last up to 6 months, the current study did not include the follow-up measures necessary to show that attentional biases and avoidance acquired through verbal information persist. Finally, these experiments do not tell us whether BIS sensitivity moderates the fear beliefs/expectancies that have been shown to be created by threat information (e.g. Field & Lawson, 2003).

Summary

This study explored the moderating role of BIS sensitivity on the effect of threat information in the development of fears. The data suggest that there is a relationship between BIS sensitivity and both behavioral (avoidance) and cognitive (attentional biases) components of the anxiety response created by threat information about a novel animal.

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APPENDICES

Appendix A: Child version of the CW-BIS

1. If I think something unpleasant is going to happen, I usually get pretty 'worked up'
2. I worry about making mistakes
3. Getting told off upsets me
4. I feel pretty worried or upset when I think or know somebody is angry at me
5. Even if something bad is about to happen to me, I don't get scared
6. I feel worried when I think I have done poorly at something
7. My friends get more scared than I do

Appendix B: Questions for Muris et al.'s (2005) adaptation of the CW-BIS

1. I usually get very tense when I think something unpleasant is going to happen
2. I worry about making mistakes
3. I am hurt when people scold me or tell me that I do something wrong
4. I feel pretty upset when I think that someone is angry with me
5. I do not become fearful or nervous, even when something bad happens to me
6. I feel worried when I think I have done poorly at something
7. I am very fearful compared to my friends

Appendix C: Information

Positive Information

Have you ever heard of a cuscus/quoll/quokka? Well, cuscuses/quolls/quokkas come from Australia. They are small and cuddly and their fur is really soft. They are very friendly, and live in the park, where they love playing with children and the other animals. If you went to the park, a cuscus/quoll/quokka might come out to see you, and you could stroke and cuddle it. Cuscuses/Quolls/Quokkas eat berries and leaves, and you could feed it out of your hand, which would make it so happy. Everyone in Australia loves cuscuses/quolls/quokkas and they like people too.

Threat Information

Have you ever heard of a cuscus/quoll/quokka? Well, cuscuses/quolls/quokkas come from Australia. They are dirty and smelly and carry lots of germs. They are very dangerous, and live in dark places in the woods, where they hunt other creatures with their long sharp teeth and claws. Cuscuses/Quolls/Quokkas eat other animals, so their favorite food is raw meat and they like to drink blood. If you went to the woods, a cuscus/quoll/quokka might be hiding there, and you might hear its ferocious growl. I don't know anyone in Australia who likes cuscuses/quolls/quokkas.

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FIGURES

- Figure 1: Graph showing the mean difference in reaction times for different types of trials on a visual dot-probe task.
- Figure 2: Graph showing the average log-transformed time to approach touch boxes containing animals about which threat, positive or no information has been heard.

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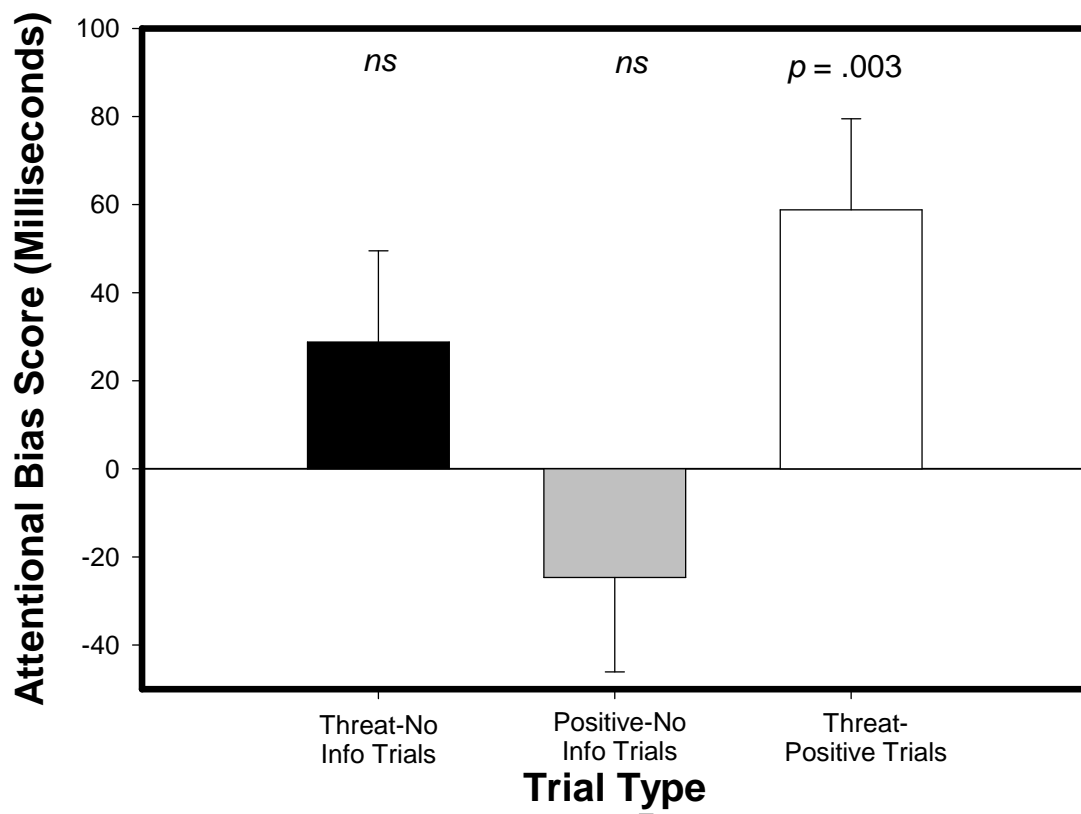


Figure 1

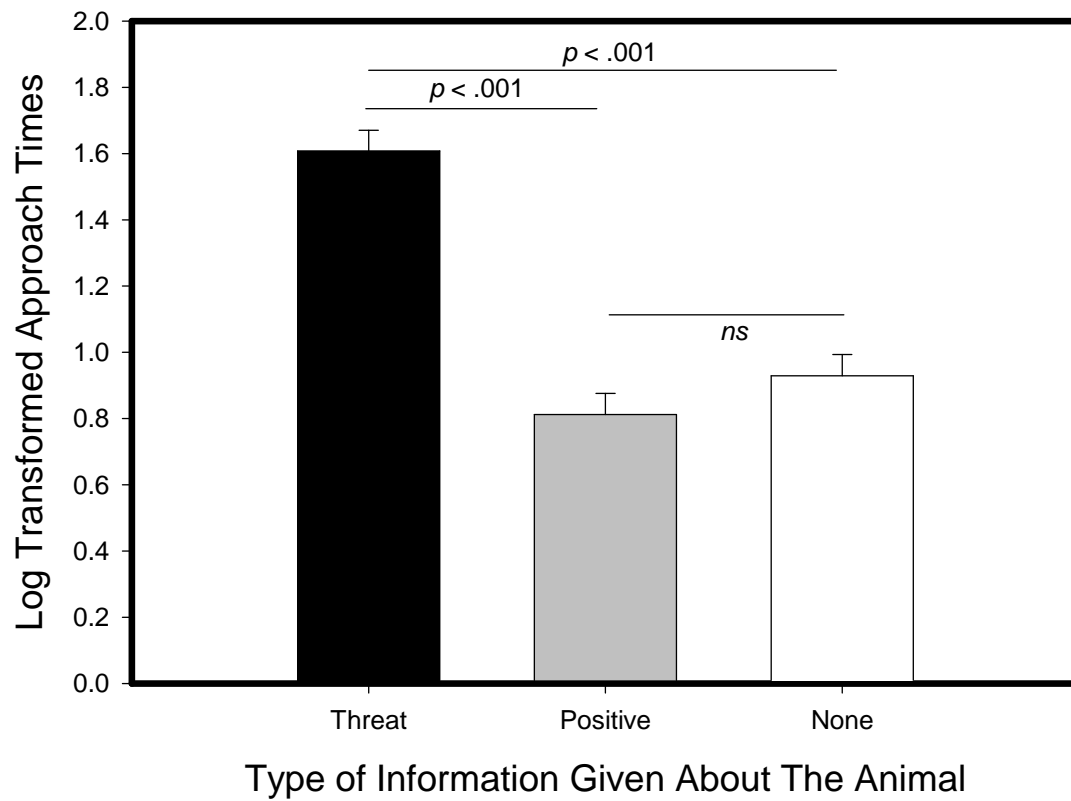


Figure 2

Footnotes

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- ⁱ It could be argued that the learning here may wholly or in part reflect vicarious learning (i.e. the facial reactions of the experimenter while reading the information may be responsible for the changes in fear beliefs and not the information). However, the basic finding that fear information changes fear beliefs has been demonstrated using a computerised version of the task in which pre-recorded digital sound files are used and a still colour image of an adult female.
- ⁱⁱ When the log-transformed reaction times were analysed rather than standard deviation adjusted reaction times, the Threatening-no information trials also produced an attentional bias significantly different from zero, $t(37) = 2.44$.
- ⁱⁱⁱ The results were unchanged when items 5 and 7 were excluded from the CW-BIS: The interaction between the first dummy variable and BIS was significant ($b = 31.61$, $SE = 10.01$, $\chi^2(1) = 9.98$, $p = .002$) as was the interaction between the second dummy variable and BIS ($b = 24.55$, $SE = 9.94$, $\chi^2(1) = 6.10$, $p = .014$).
- ^{iv} The profile of results was the same if data from these 14 children were excluded.
- ^v An analysis of the untransformed scores using a nonparametric test (Friedman's ANOVA) also revealed significant differences between approach times to the boxes, $\chi^2(2) = 140.36$, $p < .001$.
- ^{vi} The results were unchanged when items 5 and 7 were excluded from the CW-BIS: *NegNo* \times BIS interaction was significant ($b = 0.05$, $SE = 0.02$, $\chi^2(1) = 9.49$, $p < .01$) and the *PosNo* \times BIS interaction was significant ($b = -0.08$, $SE = 0.02$, $\chi^2(1) = 19.79$, $p < .001$). The profile of results was also the same when the raw latencies were analyzed rather than the log-transformed latencies.